* PHYSICAL SCIENCES
* EARTH SCIENCES
* MATHEMATICS

Fields of Work for Women

WOMEN'S BUREAU

DEPARTMENT OF LABOUR, CANADA

1964

TABLE OF CONTENTS

INTRODUCTION

A place in the world of work, in addition to and related to her role in the family and in the community, is a vital part of the life of almost every woman today. One of the most important tasks of this branch of the Department of Labour, therefore, is to help make girls aware of current developments in society that open up new opportunities of employment and to encourage them to undertake occupational preparation that will give meaning to their participation in the world of work. Within this broad purpose, the present bulletin brings to their attention the dynamic fields of the physical sciences, the earth sciences and mathematics, underlining the possibilities without ignoring the difficulties.

Frequently the girl with mechanical aptitude and a bent towards mathematics and science is steered toward other fields of study and work that seem to be less demanding or are regarded as more suited to women. The achievements of a few women pioneers in science in Canada make us realize, however, that to exclude gifted women with scientific interests from so exciting and creative fields of endeavour is to bring grave loss, not only to them but to the nation, and even the world.

The girl who wants to pursue a scientific career will have to face the fact that it will require unique continuing concentration and will demand a more dominant place in life than work in a less dynamic field. Moreover, since for most women life will include marriage and a family, these also must be kept in mind. Most important of all is that a girl be as free as possible from pressures to conformity and mediocrity and able to make life's decisions with a sense of inner authenticity. She will have special need, therefore, of the understanding and encouragement of parents and teachers as she plans and works for the future.

Such concerns as these colour the approach of this bulletin. It is not an occupational monograph. More adequate sources of occupational information are listed in the bibliography along with extensive suggestions for reading. Information about science clubs, special classes, nature study camps and science fairs has been included among ways of awakening and sustaining interest in the world of science. The bulletin is addressed, therefore, not only to girls themselves but also to the adults upon whom they must be able to rely as they venture into new fields of exploration and achievement.

The Women's Bureau is indebted to Mrs. Alice Griffiths who prepared the bulletin and to the numerous persons whom she consulted - astronomers, chemists, geologists, physicists, mathematicians, librarians, editors, directors of science fairs - people whose enthusiasm for their work includes a sense of responsibility to and for the young who are forging their way into the future.

Marion V. Royce,
Director, Women's Bureau.

Department of Labour,
Ottawa, September 1, 1964.

PHYSICAL SCIENCES - EARTH SCIENCES - MATHEMATICS

as

FIELDS OF WORK FOR WOMEN

A LOOK AT SCIENCE TODAY

The young scientist today faces one of the most exciting periods in the history of scientific development. The launching of sputniks, rocket probes into space, exploration of the upper atmosphere by means of artificial satelites, the use of instrument-carrying high-flying balloons, are all part of man's attempt to learn about the universe and its relation to our earth. Searching downwards, within and around our earth, scientists strive to increase our knowledge of its structure, properties and shape. Along with this, is the continuing and important scientific search which applies the discoveries of the sciences to urgent human problems of our day -- such as disease, hunger and malnutrition, the effects of radiation on man and his environment.

This unparalleled advance of science and technology creates new problems to be solved and new techniques to be worked out. Atomic research, for example, has led to the nuclear bomb, which in turn has created the problems of radioactive fallout and nuclear control. In answer to some of these problems, traditional fields of science change, moving in new directions to converge on other sciences and form new combinations. Then too as these new combinations or specializations progress - biophysics, biochemistry, geophysics, astrophysics - vast areas are opened for further investigation. This development shows the "wonderful mutual relevance" of the various branches of science. These changes bring not only increased opportunities for scientists, but also influence the nature of their jobs. The possibilities are unlimited.

Physical sciences, earth sciences and mathematics

The physical sciences deal with the basic laws of the physical world - the structure of matter, the nature of energy, the composition and properties of substances of the earth and its celestial bodies. Chemistry, physics and astronomy are the main divisions. Before any scientist chooses a particular branch of science for special study, a general knowledge of all other sciences is necessary, because they are so inextricably bound up with each other.

- The laws and principles of physics are applied to other areas, to become geophysics or astophysics.
- Physics merges with chemistry in the study of the molecular structure of chemical substances, where the chemist seeks to understand the physical nature of molecules, atoms and particles.

PHYSICAL SCIENCES - EARTH SCIENCES - MATHEMATICS

as

FIELDS OF WORK FOR WOMEN

A LOOK AT SCIENCE TODAY

The young scientist today faces one of the most exciting periods in the history of scientific development. The launching of sputniks, rocket probes into space, exploration of the upper atmosphere by means of artificial satellites, the use of instrument-carrying high-flying balloons, are all part of man's attempt to learn about the universe and its relation to our earth. Searching downwards, within and around our earth, scientists strive to increase our knowledge of its structure, properties and shape. Along with this, is the continuing and important scientific search which applies the discoveries of the sciences to urgent human problems of our day — such as disease, hunger and malnutrition, the effects of radiation on man and his environment.

This unparalleled advance of science and technology creates new problems to be solved and new techniques to be worked out. Atomic research, for example, has led to the nuclear bomb, which in turn has created the problems of radioactive fallout and nuclear control. In answer to some of these problems, traditional fields of science change, moving in new directions to converge on other sciences and form new combinations. Then too as these new combinations or specializations progress — biophysics, biochemistry, geophysics, astrophysics — vast areas are opened for further investigation. This development shows the "wonderful mutual relevance" of the various branches of science. These changes bring not only increased opportunities for scientists, but also influence the nature of their jobs. The possibilities are unlimited.

Physical sciences, earth sciences and mathematics

The physical sciences deal with the basic laws of the physical world - the structure of matter, the nature of energy, the composition and properties of substances of the earth and its celestial bodies. Chemistry, physics and astronomy are the main divisions. Before any scientist chooses a particular branch of science for special study, a general knowledge of all other sciences is necessary, because they are so inextricably bound up with each other.

- The laws and principles of physics are applied to other areas, to become geophysics or astophysics.

- Physics merges with chemistry in the study of the molecular structure of chemical substances, where the chemist seeks to understand the physical nature of molecules, atoms and particles.

- Physics, when it merges with problems in certain areas of biology, becomes biophysics. Today this has extended to the study of the nature of the atom and of radioactivity and its effect on living tissues.

- Chemistry and biology come together to become biochemistry in the search for an understanding of the chemical nature of plants, animals and man. The study of antibiotics such as penicillin embraces these two sciences. Agricultural and food chemists are biochemists who specialize in problems related to food production and preservation.

- Chemistry is important to geology in the study of the composition of matter, which is geochemistry.

- The data collected by the astronomer is used in many areas of science, bringing astronomy into close relationship with air and sea navigation, space vehicle development, thermonuclear research, electronics and radio communication. Astronomy also provides an excellent proving ground for developing theories of time and space. Using mathematics as its tool, it is directly involved in the studies of physics, chemistry, geology and biology.

The earth sciences are included in this study, because the laws and the techniques of the physical sciences have a direct application to them. The earth sciences comprise geology, geophysics, meteorology, and oceanography. Oceanography, for instance, involves all branches of science in the study of the ocean. A chemist will study the substances of the water; a physicist, its tides, currents, temperature, light and transmission of sound; and a marine geologist, its rocks and minerals.

Mathematics is the unifying factor and the abstract language of all sciences. It is one of the oldest fields of science as well as one of the most dynamic and rapidly expanding professions. The pure or theoretical mathematician is concerned with the development of mathematical principles and the discovery of relationships among mathematical forms. He may create a new theory or extend another in a new direction. In applied mathematics, the mathematician, working with a scientist, engineer or other specialist, develops techniques to solve practical problems. He clarifies the structure of a problem and formulates it into mathematical language. This ability is of increasing importance because of the tremendous growth of electronic computation.

The mutual relevance of the sciences is well illustrated by one young scientist, a graduate in mathematics and physics, who is doing research in the biophysics unit of a large cancer research institute. She put it this way, "I was always interested in the physical sciences and only quite recently did I realize the very intriguing problems of molecular biology and how the physical sciences could be applied to life sciences to

find out about disease and malfunction, as well as the process of life itself. The research is more rewarding to me than any problems I've ever tackled in the physical science field; the challenge is unlimited."

Career opportunities

The wide range of career opportunities in the fields of physical sciences, earth sciences and mathematics are on two levels: the highly trained professional scientist who undertakes research or teaching and the technician or assistant who works with the scientist.

The demand for highly trained scientists and technicians is increasing. Indications are that in the next ten years a growing supply of teachers and research scientists will be of vital importance, particularly in the universities. The greatest need would seem to be in the fields of physics and mathematics. This situation exists not only in Canada, but in other countries as well. While the earth sciences will continue to expand and develop in new directions, the opportunities for employment are likely to be more limited than in the physical science field.

HOW DO WOMEN FIT INTO THIS PICTURE?

Will women find opportunities as readily as men to function as highly trained scientists in jobs that are satisfying and on a level with their training? That their services are urgently needed is beyond question.

In the past, the number of Canadian women active professionally in the sciences, in comparison to men, has been relatively small, but the calibre of these women and the contribution they have made and continue to make, is noteworthy.

Dr. Helen Hogg, the new president of the Royal Canadian Institute, is a shining example of a woman who has successfully combined marriage, family and a career in astronomy. As a research worker, her studies concentrate on "variable stars in globular clusters". Through years of telescopic observations, she has photographed and studied these symmetrical circular clusters of stars, and has made a significant contribution to this branch of astronomical research. Recently an important discovery was made from some of her photographic plates, by Dr. Amelia Wehlau of the Hume Cronyn Observatory, London, Ontario. Dr. Wehlau discovered through her studies of these plates, a "nova" or new star. This was the first ever to be photographed in a globular cluster and Dr. Wehlau's exciting discovery was based on work done by Dr. Hogg.

Dr. A. Vibert Douglas is also one of Canada's leading astronomers. Women like Dr. Douglas and Dr. Hogg not only have taken an active part in research but are busy university teachers, lecture to the public, write, and contribute to international science gatherings and projects. They have led the way for other women in astronomy. This branch of science, while small in comparison with some of the other sciences, sparkles with creative activity and seems to contain within its ranks a proportionately large group of able women.

In geology, Dr. Alice Wilson who recently died at the age of 82, will always be known for her authoritative studies of the Ottawa Valley and its regions. She was the first woman to be made Fellow of the Royal Society of Canada, a great honour for a scientist. As an early woman scientist employed by the Geological Survey, a branch of the Department of Mines and Technical Surveys, her first assigned task was to classify and catalogue fossils. This led to study and research in stratigraphic palaeontology, which became her speciality. To her friends, Dr. Wilson was a fine example of the passionately devoted scientist, completely dedicated to her science, working at it ceaselessly, even after retirement. She had the exceptional quality of being able to inspire others by her own enthusiasm. That a scientist share his or her knowledge with others was of cardinal importance to her, as shown in her conversations, her teaching and in her writings. (She wrote "The Earth Beneath our Feet", a book on geology for young people.) She continually stressed the need for more science writers who could make their subject understandable and enjoyable to the general public.

The philosophical nature of geology also appealed to Dr. Wilson. She emphasized that the geological study of the earth gives one a concept of time and evolution that is applicable to all life. She believed that the methods of science produce an attitude of independent search and thinking. No truer words could be said of her, than those expressed in the Citation when she received her doctorate from Carleton University a few years ago - "... Alice Evelyn Wilson, explorer of the secrets beneath us, animator of the young."

There have been other women scientists like these, women who by their ability and courage in the face of all kinds of difficulties (some of which the rising generation will never have to face) have quietly established a place for women in the world of science. Their efforts have helped in large measure to improve the opportunities for women in science.

Younger women, too, are doing distinguished work in science. We have noted Dr. Amelia Wehlau's discovery in astronomical research. Another recent achievement was the winning of the Sloan Foundation Award by Dr. Charlotte Froese of the University of British Columbia. She is the first woman mathematician to receive this honour. Her research, conducted at the Harvard College Observatory, centres on the application of mathematics and computers to the study of atomic structures.

Writing and editing occupy many of our women scientists. As specialists who teach or do research, some of them contribute to professional science journals. They have also written for the general reader everything from newspaper columns such as Dr. Helen Hogg's articles for astronomy fans, to guides for star gazers such as the "Observer's Handbook" edited by Ruth Northcott; from the museum publications of Dr. Medeleine Fritz to government booklets for naturalists such as Helen Belyea's "The Story of the Mountains in Banff National Park" or "Rocks and Minerals for the Collector: Sudbury to Winnipeg" by Ann P. Sabina; and from technical handbooks, such as the guide to aluminum products of Alcan by Audrey Rushbrook, to a book such as Dorothy Harper's "Isotopes in Action" which throws light on still another aspect of science.

These women in the physical sciences, earth sciences and mathematics, along with many others, working in their chosen specializations, are showing that with talent and skill plus character and determination, a woman, no less than a man, may build a career in science.

This brings us to the question - <u>What are the difficulties</u> which are encountered in these branches of the scientific professions and what are the attributes of women who succeed as scientists?

If we look at the traditional role of women in our society, some of the difficulties women meet in the science world might be better understood. The fact that society differentiates between what is man's work and what is woman's work, may contribute to the feeling that science is not for girls. From birth, society tends to impose certain patterns of behaviour and character on both boys and girls. A girl is considered "different" if

she pursues an interest in science and chooses it for a career. A boy, on the other hand, is likely to be encouraged to carry out his science projects and interests in every way possible. As one scientist puts it: "The female science student at university must catch up in a great deal of fundamental knowledge which the male student learned as a boy."

Some interesting light has been thrown on this aspect of society's attitude, in a recent survey conducted in several American universities. A research project of the Radcliffe Institute of Independent Study investigated the background of girls who have succeeded as scientists. It found that these girls tended to come from two contrasting kinds of homes in neither of which status was important. On the one hand, the parents were highly educated and inclined to give their daughters an atmosphere of security and encouragement; and on the other, the parents had had little educational opportunity and the practical had the most powerful appeal.

The study concludes that those at the top are secure enough to dare to be different, while bright girls from homes where the parents have had limited opportunities, are not influenced by the need to maintain a certain status. It is "the girl in the middle" who often is "less inclined to venture from the traditional woman's role."

For and against a career in science

In our society, the emphasis on a woman's traditional role has considerable effect on a girl when she chooses a career, often on the teacher who instructs and guides her and even on the employer who hires her. Within the science field, there are some branches that attract her more than others. She tends to choose biology and chemistry. Geology, the related earth sciences and engineering seem less apt to interest her.

The nature of the earth sciences, as they are studied and developed in Canada, is a primary factor in limiting the number of women who choose them. These are male-dominated sciences, mainly because the physical aspects of their activity have been stressed. A scientist or engineer may be called upon to perform mechanical functions such as installation and construction (often using heavy equipment) or to undertake rigorous field projects, living under primitive and isolated conditions.

A geologist now working on her Ph.D. in England has this to say of geology in Canada, "Geology is still very much a profession of the field ... and unfortunately ... used mainly as a tool to prospecting. In Great Britain, where mineral resources are virtually lacking, it has developed much more as a stratigraphic field, and the philosophic implications seem more widely appreciated by the public."

Many of the physical hazards connected with these 'energetic' scientific occupations are however becoming less of a problem. The development of new equipment, new tools and new techniques is changing the nature of many jobs.

Isolation in lonely, unprotected regions for field observations is another limiting factor on the numbers of women in the earch sciences, in which trips or cruises are a vital part of training and research. Here too, however, changes are occurring. As more women enter these fields - and there are a few more each year - it will become easier for them to make field trips together. Moreover, many of the 'remote' areas are becoming less isolated.

A palaeontologist, who is doing research in marine biology, when asked about this aspect of her work said that although there are many difficulties she has been able to arrange for her trips in areas that have not been too isolated and where living accommodations have not been too primitive. Some of these trips were taken on her own. She adds that a geologist should be reasonably healthy, be able to adapt to outdoor living and have self-reliance.

Oceanography and meteorology present women with more difficulties than some other fields. In the past, Canada's floating laboratories have not included women scientists on their cruises. The "Hudson", however, just recently launched, is equipped with a suite for women. This, no doubt, will mean that in the future women scientists will go to sea on science research cruises. As yet, they have been more or less confined to shore laboratories and teaching in universities. Women are not encouraged to study meteorology, because its activities hinge on weather forecasting, and the training requires study and work in posts that are remote and male-staffed.

The sciences are linked in the practice of engineering. So too, the difficulties encountered by women are concentrated in the engineering field. The few women who have become engineers seem to favour electrical or mechanical rather than civil engineering, where strenuous outdoor activities, surveying and field trips have been predominant. But changes are also taking place in engineering as technology advances. Mr. Garnet Page, Secretary of the Engineering Institute of Canada, writes, "Opportunities for women in many areas of engineering are increasing, particularly as they become more sophisticated and less of the traditional 'outdoor' type of thing."

Marriage and a career in science

Marriage as well as a career is an important goal for most girls. The growing tendency is to marry early (before the age of 25). Many women continue to work, often because of financial necessity. For the years of child raising, most leave their work, however, returning later, usually in their thirties, when their children are older. Also pertinent is the fact that women are living longer than in the past. As a result of such factors, a woman's work expectancy is increasing. A girl can expect to work for 25 years. If work and marriage are combined or if she remains single, her working life will be somewhat longer.

If such a large part of a woman's life is to be spent as a wage-earner, it is important that her work should utilize her capabilities and be satisfying to her. There is a tendency in our society, however, for girls to think only in terms of marriage, without any perspective on the whole of a woman's life. The importance of education for a 'career' is, therefore, discounted in favour of short-time preparation for just a 'job'. A career in science requires a long and intense preparation, and the girl who wants to be a scientist must consider the whole span of life in order to make a place for the two major roles in the life of a woman - marriage and a career.

For the woman scientist this combination is particularly difficult. She must keep up-to-date in her work and, as the developments in science are so dynamic, she can do so only if she is constantly at work. In marriage, if raising a family is part of it, very few women are able to continue to work on a full-time basis. The scientific pursuit requires complete dedication and concentration - and is also time-consuming. Home problems may affect this concentration. As one scientist has remarked, "When home crisis and work crisis coincide, that's when the going is hard."

Nevertheless, there are women of ability who hold valuable positions in science who have successfully combined the raising of a family with a career. They have been able to do this because certain factors have been present: a job that is somewhat flexible, where work may be organized for the scientist's convenience; a home situation which is satisfactory for all, where arrangements for help are sufficient; a husband who respects his wife's capacities and her desire to use them; and finally a job which is challenging and makes it all worthwhile.

Re-entry into a scientific profession for a married woman after a number of years' absence, is especially difficult. There is considerable catching-up to do. This may mean taking a refresher course and finding a job at a lower level than the one for which she is qualified. She may need to take a part-time job and earn and learn at the same time. Some married women trained in the sciences prefer to "swing a part-time job" because it enables them to combine home and family with interesting work without too much "wear and tear."

Some find an answer in work which may be done at home, such as the analysis of technical literature, translation, writing book reviews, or sometimes work done in conjunction with a research project where only an occasional visit to the research centre is necessary. Free-lance writing, also, has possibilities for a woman who wants or needs to be at home.

Others prefer jobs outside the home as laboratory demonstrators, research assistants, lecturers, technicians, supply teachers, computer programmers or librarians.

It is evident that, for a dedicated scientist, marriage is not an insurmountable obstacle to a career. If she is of high calibre and has advanced in her profession, she will find ways of staying at her job. If she must leave, she will make the time as short as possible and will keep up-to-date with her specialization.

There are many women, however, who have found the difficulties overwhelming and have never returned. Some of these have married while still very young and require further education and experience. Ways and means must be developed to make it possible for women of ability, who may or may not have received sufficient education, to re-enter their chosen science field, to continue their education or catch up on their speciality and to find a place in the working world.

A number of experiments and programs which have been undertaken by universities in the United States are designed to meet this pressing problem. The Radcliffe Institute for Independent Study is one noteworthy example. Guidance to help women who wish to re-enter their professions to select courses of study, scholarships to assist them financially, facilities to enable them to carry on their studies or research are all part of the Institute's program. The opportunity to "continue" or to "commence" their education, will become increasingly important for married women. This means more re-training programs, more part-time jobs and a more open-minded attitude on the part of employers toward employing married women.

Attributes of the scientist

There are a number of abilities and qualities common to all scientists of worth, men and women. Mathematical aptitude as well as excellence and intense interest in science are essentials. To the mathematician, the logic and conciseness, the aesthetic beauty of mathematics and the versatility of its application, have special appeal. The creative scientist has a well-developed imagination and ability to think abstractly. The sciences arouse curiosity and appeal because they present a challenge to explore and discover the unknown, stimulating originality of thought and presenting possibilities for contributing to the well-being of humanity. This humanitarian aspect, the Radcliffe Survey found, has considerable appeal for girls in science.

The girl who has a genuine interest in science will find ways of learning about it and will make plans for her future. Knowing the direction of her life, that it is to be in science, she can then utilize her education in the best way possible. The decision about a particular specialization will come later, probably when she graduates from university and must choose her field of post-graduate study and research. Her plans will include the possibility of marriage and children, but generally not until her studies have been completed (about the age of 25). It would also follow that her hopes would be to return eventually to her profession. With high "theoretical values", a certain built-in-security, definite goals and high priorities, she is able to go ahead on her own initiative and work out her plans. The question of being different does not worry her.

The success of a woman in science will be in large measure due to her ability to carry out plans for obtaining the best education possible in her field of specialization. Her next step will come when she chooses

science as a "career", not just a "job" to put in time before marriage. Her career becomes part of her life plan which may include marriage. As a result, her chances of obtaining and maintaining a satisfying position will be increased.

A university teacher and research worker writes: "The field in which I am engaged, Electron Microscopy, contains several women who are established leaders in their own specialities. I don't think there is a selection either for or against women, rather we seem to have reached the stage that if a woman has ability she is invited to go ahead and prove it."

OCCUPATIONS

TEACHING - Secondary School Level

Teaching offers excellent opportunities for interesting and satisfying work. The demand for competent teachers of science and mathematics is urgent. Also, a teacher who has proven herself at home may find challenging openings in some of the newly developing countries where the shortage is even more acute.

The science teacher has a vital role in the 20th Century. She has a unique opportunity to detect and quicken interest in scientific understanding and pursuits. She does this by her knowledge, teaching ability and enthusiasm. Scientists who have advanced in their profession, frequently attribute their initial interest in science to a teacher. To provide the climate for the growth of an attitude of independent study and thinking, to help the student apply the scientific method to all his work, is a very special privilege of the science teacher.

- A research chemist tells us that her chemistry classes in high school were much the most interesting of all, because the teacher often livened them up with dramatic stories of the uses of chemistry in everyday life, particularly of how it could be used in crime detection!

- One Science Fair finalist says she first became interested in science in Grade VII when they started experiments. She goes on to say, "The year that I was in Grade X was the first year of our local Science Fair. Each of us had to build a Science Fair project. We didn't have to enter it but we did have to build one. I entered mine".

Since high school years are not the time for specialization, it is important that a student at that stage have the opportunity to develop an 'over-all view' of science. Exciting new developments based on the interrelationship of the sciences may not be in the curriculum, but the teacher has the opportunity to infuse them into her teaching. For instance, sciences such as astronomy and geology, which are seldom taught as subjects in high school, have vital connections with physics, chemistry and mathematics.

- A scientist whose speciality is electron microscopy writes, "The basic quality of physics and mathematics and how knowledge in these fields is essential for so much now happening in other fields should be pointed out".

School curriculums are frequently revised and sometimes completely changed. With scientific developments and changing needs, teaching methods and subject matter are affected. The new way of teaching

mathematics with emphasis on structure and meaning rather than technique is an example of a problem-solving approach to teaching which may change curriculums at all school levels.

A specialized background in science or mathematics is important. An honours degree in mathematics, physics and chemistry plus the required year of teacher training and some teaching experience, brings the best teaching positions. A bachelor degree from a general science course, with careful selection of options, is also a good preparation for high school teaching in some provinces.

Planning early for a teaching career helps in making the best use of the university years. While encouraging a more intensive study of one particular science field, consideration for the humanities must not be overlooked. Communication between the sciences and the humanities and the search for relationships is of concern to thinking people of our day. Robert Oppenheimer has said:

> ... Today, ... it is almost wholly through the arts that we have a living reminder of the terror, of the nobility of what we can be, and what we are ... I believe that the idea of the improvement of human life on earth provided the air for the great fires of science.

C. P. Snow sees the task of education of prime importance:

> With good fortune ... we can educate a large proportion of our better minds so that they are not ignorant of imaginative experience, both in the arts and in science, nor ignorant either of the endowments of applied science, of the remediable suffering of most of their fellow humans, and of the responsibilities which, once they are seen, cannot be denied.

In choosing the most suitable course of study, the prospective teacher may obtain help from the high school principal, guidance counsellor or science teacher and also from the nearest university or teachers' college registrar.

TEACHING - University Level

In the next ten years, universities will be expanding rapidly and will be increasing in numbers. The student population is expected to more than double. The demand for university teachers will be acute, and women who have specialized in the sciences may well be attracted to teaching at the university level.

In the universities the ferment of ideas and investigation is evident, for that is where so much of the research is done. The impact of ideas and discoveries often brings changes in traditional courses of study. New courses may be organized providing excellent and exciting

opportunities for teaching and research. Working with other scientists, many of superior intellectual calibre, all of whom are seriously employed in investigation and teaching, makes for a rich experience. The interaction of scientists with one another and with eager students is a continuing challenge.

University teaching does not require a formal teacher's training course, but the basic educational requirements are high. At least one post-graduate degree (M.A.) and more often a second degree (Ph.D.) as well, are necessary. Part-time teaching is sometimes possible while working toward an advanced degree.

Salaries and opportunities for advancement vary from one university to another and from department to department. For women teachers the variation is even greater than for men, depending upon the particular attitude toward women, especially married women, in the profession.

Research

The purpose of scientific research is twofold - to search for knowledge and understanding of the natural world, which is pure or theoretical research, and to control and use this basic knowledge in solving the problems of man and society, which is applied research. Both aspects encompass experiment in a laboratory and require ability to analyze, correlate facts and draw logical conclusions, all inherent in the scientific method. Sometimes the theoretical and the applied merge in the research activities of one scientist. Physicists for instance, may design and develop devices or instruments with which to continue their research. This was so in the case of the invention of the atomic reactor and the transistor, which were the "creations of theoretical physicists who developed their inventions in the course of fundamental research".

Professional research scientists are highly specialized, concentrating on one particular area of science, with its special concepts, techniques and vocabulary. Tools and techniques are used in common when specializations touch or overlap. Chemists studying the structure of the molecule may use the analytical tools of the physicist, such as the spectroscope or the electron microscope. Much of the work in chemical research requires detailed intricate activity where the chemist must study and measure substances or undertake analysis and testing, using such instruments as the chemical balance or the radioactive isotope counter. The physicist may use everything from the electron microscope to large-scale apparatus and equipment such as the linear electron accelerator, which is so vital to nuclear physics research. Astronomers undertake all kinds of observations which involve analytical measuring activity. They use a variety of instruments, from complex photographic equipment to the major tool, the telescope and sometimes even spacecraft.

The electronic computer has been a welcome addition to the array of tools and instruments at the disposition of scientists and mathematicians. It is the spectacular outcome of laborious, and at times fruitless, research dating as far back as Charles Babbage and the "analytic engine" which he designed and partly built more than one hundred years ago. The automatic sequence controlled calculator or Mark I, completed in 1944, is similar to the "analytic engine" with Babbage's sequential control principle adapted to the use of electromagnetic relays.

Today, twenty years and many improvements later, scientists and mathematicians use the computer to solve many of their most complex problems. Mathematical manipulations which, because of their scope, had hitherto been outside the realm of possibility are now envisaged with anticipation. Dr. Charlotte Froese, mathematician, in describing her research project at the Harvard College Observatory expresses her interest in:

> ... the application of computers and mathematics to the solution of problems in science, particularly in the study of atomic structures. This is an area in which certain experiments are not feasible and theoretical results are required for analyzing data, such as those received from rocket and satellite observations of the solar corona. The temperatures and pressures are so extreme in the sun that these cannot be reproduced in a laboratory set-up. Theoretical calculations are necessary to determine the behaviour of atoms in such an environment

Some scientists may rely on programmers who have sufficient knowledge of the field of science to understand the problem and solve it by means of the computer. Dr. Froese emphasizes that for programming in scientific areas a general education in science and mathematics is essential. Further she adds that in many areas a knowledge of statistics is of prime importance.

The general trend today is for prospective scientists and mathematicians to receive instructions in the use of a computer as part of their university education and to use it as any other scientific tool at their disposal. Employment opportunities in the electronic computer field tend to be concentrated in the area of office data processing, where the computer installation may be very different to that found in scientific areas.

Research scientists work together in closely knit groups, checking and arguing with each other, often confronted by set-backs and tedium, at times excited about rewarding discoveries. These working teams draw upon other specialities for assistance and find new directions for investigation. These are the professionals, who are in turn part of a larger community of scientists in the same field who, by their association, cut across boundaries of country, race and even language.

A remarkable example of the international nature of scientific research is the recent break-through in atom-smashing physics - the spectacular discovery of the "Omega-minus" particle, its nature and the orderly pattern into which it fits with nine other particles.

In 1959 a Japanese mathematician, Y. Ohnuki, suggested that the pattern of particles could be studied by the use of a mathematical device called a unitary transformation. Later, proceeding on this basis, a group of physicists at the Imperial College in London, England, carried out a study of the structure of matter. The group consisted of Professor Abdus Salam, the brilliant Pakistani physicist, Professor John Ward, from Oxford University, and Yaval Ne'eman, an Israeli research student with engineering experience. Independently, at the California Institute of Technology, Professor Murray Gell-Mann, also a theoretical physicist, arrived at the same answers as the London team.

In their study of the nature of the pattern of the particles, they found that a definite symmetrical pattern was formed, which consisted of ten particles, nine of which were already known. This was in 1961. By 1963, because of this work in predicting the character and position of the tenth particle, a group of American scientists at the Brookhaven National Laboratory on Long Island, led by Dr. R.P. Shutt, experimented and verified the earlier prediction of the Omega-minus particle. They determined its position and the nature of its splinter-like action. This dramatic piece of scientific investigation, brought to an end this particular branch of nuclear physics and marked the beginning of a new understanding of the "structure of matter and the forces which hold the nuclei of atom so firmly together."

"The International Year of the Quiet Sun" is another example of international cooperation in scientific research. The conditions for upper atmosphere research are at their best from 1964 to 1965. This is the quiet phase of the sun and so provides an excellent opportunity for observation. A giant cooperative scheme has therefore been launched to find out as much as possible before the cycle of sunspot activity starts all over again. Canada is taking an active part in this project as part of its over-all space research plan. During the "International Year of the Quiet Sun", the Canadian government's cosmic ray stations are exchanging data with other such stations the world over.

Canada has developed its own pattern of research activity, influenced considerably by its large territory, scattered population, the nature of its economy and particularly the stage of its industrial growth. Research is carried on in federal and provincial government agencies, in research foundations, in the universities and to some degree in industry.

The research centres that have the money, facilities and staff, cooperate with each other to make the best use of these for furthering research. The National Research Council, a federal government agency, frequently contracts specific research projects in the universities or in industry, while still carrying on an immense amount of research in its own laboratories. So too, various departments of the federal and provincial governments, cooperate with industry and other groups to solve industrial, regional and local problems. If it lacks research resources, an industry may contract a project in a university or government department. The food and drug industries, for instance, may subsidize research in nutritional or pharmacological problems.

The Ontario Heart Foundation, a private research organization, recently delegated the Faculty of Food Sciences, University of Toronto, to make a study of sodium-restricted diets and to develop diagnostic foods for the treatment of certain heart diseases, hypertension and nephritis.

Out of this network of interlocking science research, Canada has developed "a very strong committee system". An example of this system is seen in the "Associate Committee on Space Research", which conducts a large-scale research program. The Committee is comprised of the National Research Council and other government research agencies along with seven universities and various industries. Canada's high altitude research has been conducted under this unified plan. The launching of the "Alouette", the space probes with rockets, balloons and satellites, the building of a radar laboratory, the study of the effects of the magnetic field over Canada and of the northern lights on radio communication, the development of communication satellites, have all been part of this cooperative research planning.

Qualifications for research depend on the nature of the scientific investigation and on the position of the research worker in the hierarchy of the research enterprise. At least one university degree is necessary. A reading knowledge of at least two other languages is valuable and obligatory in some science courses. A bachelor degree in science may be enough for an assistant's position. Often assistant research work will lead to a post-graduate degree. A Ph.D. (which means seven or eight years of university study) is absolutely necessary for the top levels of research. The more experience and training obtained, the more interesting and rewarding the work.

Apart from academic qualifications, certain personal attributes are necessary. These have been discussed elsewhere in this study, but should be emphasized again - capacity to engage in logical and highly abstract thought, imaginative insight, insatiable curiosity and the ability to do rigorous work which in most cases calls for discipline and patience.

Research takes place where there are needs, facilities and money for the job to be done. Research workers move around, according to where they can learn the most and where they are needed. Then too, out of research findings, a scientist may acquire new insights that take him or her in another direction. This is the exciting part of scientific research. This is the developing aspect of a scientific career.

- One scientist, who began her career as a chemist in pure research, found herself gradually attracted to biological chemistry developments. She proceeded to do some post-graduate study in this, and now is engaged in hormone research in an agricultural animal research department, as a biochemist.

- A "Computer Systems Programmer" whose training has been in mathematics got her first job in the accounting department of a government research centre. Working on a hand-operated computing

machine in the office, she became interested in computing. She was able to qualify for a transfer to another department where the programming of an electronic computer for engineering problem-solving was more of a challenge. "With further mathematical training, this work should become more interesting", she says. "A research worker just never stops learning!"

- A mathematics and physics university graduate, through summer employment in a hospital laboratory, became interested in the application of the principles of physics to biological research in the field of medicine. She is now working on her Ph.D. and teaching in the biophysics department of a cancer research centre.

When considering the universities and their research opportunities, it is easy to overlook valuable areas of scientific activity which do not fall into traditional divisions of science. Courses of study which have new names and new alignments may offer attractive opportunities for scientific research in the physical sciences.

- The Faculty of Food Science in the University of Toronto (formerly the Department of Household Science) stresses science training and specialization in relation to food, nutrition and textiles. Then again, sometimes a unit which specializes in one of the physical sciences will be tucked away in some other department or faculty. A medical faculty may have a chemistry department which specializes in allergies. Or again, a department of physics specializing in radiation physics may be working with a university medical faculty in research and teaching. Also important and sometimes forgotten is the research related to the geological sciences which is undertaken by museums.

• Federal government agencies and departments, as well as those of provincial governments, offer excellent opportunities for scientists and mathematicians.

- The National Research Council employs many scientists for both pure and applied research.

- The Department of National Health and Welfare employs some physical scientists in its research in nutrition and pharmacology.

- The Department of Agriculture needs physical scientists to work in the plant, animal and food divisions of its Research Institute.

- The Department of Mines and Technical Surveys employs many scientists, particularly in the geological and related

earth sciences - "everything from palaeontology to biogeochemistry, from electronic computers to neutron generators ..." and also includes Canada's three Observatories for astronomical research - Ottawa, which specializes in positional astronomy, Victoria in star spectrography and Penticton in radio-astrophysics.

- The Dominion Bureau of Statistics employs mathematicians as statisticians, who analyze data and provide mathematical solutions to problems.

Not to be overlooked in the research picture, are the many mathematicians employed in research projects as statisticians, actuarial mathematicians or as numerical analysts in the electronic computer field.

Good, highly qualified scientists may also find opportunities for research and teaching in other countries. "International cooperation in science and social development" is part of the United Nations policy. It has set up a program to provide means for scientists and technicians of the 'developed' nations to assist less developed countries in training scientists and in carrying out scientific research. In Canada, the government, the universities and many organizations are cooperating in this movement. They assist financially so that research scientists and teachers may be sent abroad to the countries that need them.

Library Work

There is an urgent need today for more trained librarians who have specialized in science or engineering. Librarians with a science background will find a great variety of opportunities, whether in the general type of science library or working with more specialized collections. These library positions occur in industry, in federal and provincial government agencies and departments which concentrate on research, such as the National Research Council, in research foundations, in science divisions of university libraries and in large public libraries with science or technical departments.

The rapid advance of scientific research and the technological developments that accompany it have resulted in a massive stream of scientific literature. Scientists have estimated that there is a doubling of scientific knowledge every ten years. In fifteen years, the volume of chemical abstracts alone has quadrupled. One American firm has figured that "for any research costing less than $100,000, it is simpler to repeat the research, than hunt for existing papers on the problem ...".

The scientist, in seeking information for a research project, can no longer depend upon traditional library organization and method to obtain it. "Instead of one or two sources for his information, he must now consult fifteen, and still not find what he is looking for. This has led to frustration, to irritation with the older established forms which have

traditionally organized scientific knowledge by disciplines, and to almost frantic effort to invent new forms, new institutions, new devices which he thinks may solve the problem for him."

The problem of abstracting, indexing, storing this flood of scientific literature and of applying it to the needs of the scientist, efficiently and quickly, has become extremely complicated and difficult. A re-examination of the place of the library and the librarian in the dynamic scientific world of today is taking place. Traditional modes of library practice and old concepts of the qualifications of the librarian, especially the science librarian, must of necessity change if the library is to fulfil its responsibility as an information centre for scientists.

Streamlining of library procedures and increased mechanization have been occurring in libraries for some years. For example, the National Research library, to meet the growing problem of listing its publications, periodicals and other serials for the use of other science libraries, has developed a mechanized system of its own. It also uses a data processing type of computer for indexing.

Also, the use of computing equipment in the organization and retrieval of information is increasingly displacing traditional methods of cataloguing and classifying library material. Recently in the United States the Library of Congress, pressed by its growing problems of research operation, appointed a "survey team" to look into the possible application of automation. This committee confirmed the view that in large research libraries the use of such devices is now technically and economically feasible.

The educational qualifications of a science librarian, therefore, call for a broad range of knowledge. In university undergraduate studies, the humanities as well as sciences, should be included. The minimum requirement for entrance into the one-year course at an accredited library school, if a science library is the goal, is a bachelor's degree in science or in arts (with mathematics and science options). Here again, as for teaching and research, a reading knowledge of at least two other languages is advisable. Post-graduate study for the science librarian may be essential if he or she is to serve in a specialized science library.

In addition to these academic requirements, the personal attributes that befit all good librarians are important - imaginative curiosity in and enjoyment of the search, the desire to assist others in their pursuit of knowledge and ability to work with people.

A scientist who chooses librarianship as her profession, will find it a challenging and satisfying career. The excitement of scientific research may be hers too, in her cooperation with the research scientist. There will never be a dull moment! The science world changes, so she too will change. In a lifetime career that includes marriage, library work offers needed flexibility, and part-time schedules, often an important consideration for a married librarian, may be possible.

Scientific Writing

Writing about science and technology is fast becoming a profession. It requires writing skills and a background of education in science. Its functions are increasingly important in our society. The language of science and the vocabulary of each speciality is different, much of it not understandable even to other scientists. The writer comes as the interpreter, putting the specialized information into terms of every-day life.

Scientific writers include both the science editor or writer who writes and edits for other scientists and the technical writer or science journalist who writes for the general public.

Science editors are usually trained scientists and may often combine editing with teaching or research. They may be responsible for editing research material or the proceedings of scientific societies, or producing a scientific journal. Editors not only must be able to prepare articles for publication, shaping and clarifying the presentation, but also require knowledge of printing processes and techniques.

Technical writers may produce manuals or brochures about some particular aspect of science or technology. Sometimes they are employed by an industry to describe a product or by an organization to explain some feature of its work. They will do their own research on the subject, consulting the scientists, interpreting their findings in simple non-technical language, arranging for illustrations and finally guiding the material through publication. Occasionally such writers are asked to prepare reports on a technical subject or a research project for the use of management. The writing of publicity material or sales letters may be assigned to them. Such writers are often employed on a free-lance basis. Sometimes the technical writer may be the librarian in an organization. There are many variations and combinations of scientific writing.

Scientific journalists do still another type of scientific writing for general consumption. Popular articles or books on science call for writers of ability with a science background. If the discoveries in science are to have an honest effect on human culture, they must be understandable. The problem of communication between the disciplines, between science and the humanities, weighs upon the minds of many contemporary scientists, philosophers, artists and teachers. Scientists who have the gift of expression may be able to help by explaining or illuminating the discoveries and truths of science.

There are no hard and fast rules for training as a science writer. There are, however, some essentials - a university degree in science with broad knowledge of languages and literature, as well as ability to organize material and to write clearly. In some cases, a post-graduate degree in a science speciality is necessary.

A woman scientist who is also a writer has said, "Technical editing and women scientists are made for each other." This holds true for all forms of scientific writing. It is a flexible occupation, operative full-time or part-time, and, therefore, an inviting field for the married woman who is qualified.

Technicians

In scientific research, for every brilliant initiator, there are numbers of capable people who work as assistants. Many such workers, employed in the science laboratories or in field work, carrying out the instructions of the supervisor, are highly trained scientists who are there to gain experience and training as they advance in the profession. There are many, however, in these laboratories who are employed as technicians and who play an important part in a research project. They are the non-professionals, the skilled assistants.

The qualifications for a technician vary with the nature of the scientific work. Generally, the requirement is a high school certificate plus post-high school training in an approved institute of technology. This may take from two to three years, with science and mathematics as the main subjects. In addition, because of the exacting, detailed work in a science laboratory, the technician must have patience, thoroughness, manual dexterity and preciseness.

A research supervisor in a large industrial laboratory made this further comment regarding the qualities of a good technician: "I would put reliability and complete honesty first ... Much scientific work is tedious and repetitive ...".

Opportunities for women who are trained as technicians are numerous in the physical sciences. They will be found wherever there is research, basic or applied, in the laboratories of government, industry or university. Some technicians, by adding to their experience and taking further training in a science speciality, may advance from the technical level. The combining of work and education is more and more possible. Technician work in some laboratories may be adaptable to part-time work, a fact which makes it attractive to married women.

FINANCING AN EDUCATION

Worthwhile opportunities in the science field are available only to the highly-trained scientist. For many students who have ability and are serious about a science career, to finance the required education would be extremely difficult, even impossible, without assistance and careful planning.

Scholarships, fellowships, bursaries and loans

Happily there are numerous sources of help - scholarships, fellowships, bursaries and loans. Many of these are available to students in technical institutes as well as to those in the universities.

Scholarships, bursaries and other awards vary in value from sums that cover the complete cost of a course to smaller amounts and they extend over differing time periods. Some are based on the student's financial need and ability to pay fees. Students should collect the facts about the nature, the extent and the requirements of each award they seek.

The needed information may be obtained from the high school principal or from the registrars of universities and technical institutes. University calendars include scholarship information for the individual university. The student should have the necessary information well in hand before the final year of high school has started.

Government agencies, industrial and business firms, educational institutions, scientific societies and private foundations, offer a variety of scholarships and loan funds to worthy students.

The Royal Canadian Institute offers scholarships each year to the two top science students entering their final undergraduate year in any university.

The Imperial Order of the Daughters of the Empire and also the Canadian Federation of Business and Professional Women's Clubs are organizations that contribute substantial amounts in scholarships every year, many of them for science.

The Canadian Federation of University Women each year offers four valuable scholarships or fellowships. Two of these are for study abroad. One, the A. Vibert Douglas Fellowship, is unrestricted as to subject, place of research and whether for graduate or undergraduate study. In 1964, the Fellowship amounted to $2,000.

The Zonta International recently awarded a $2,500 Amelia Earhart Scholarship to a Canadian woman scientist who is now undertaking postgraduate research at the Institute of Aerospace Studies, University of Toronto.

The National Research Council not only offers a number of science scholarships for study in its own laboratories, but also takes part in a NATO

plan for the international exchange of students. In 1964-65 it awarded 26 such science scholarships for Canadians to undertake post-graduate or post-doctorate study abroad.

Loans are available from various sources; in order to ensure the most favourable terms the student should seek the advice of the registrar of the institution where she is studying. A new source of students loans was established during the current session of Parliament when The Canadian Student Loans Act was passed. Under this legislation the designated authority in each province that takes part in the plan may sanction bank loans of $1,000. a year up to a total of $5,000. for full-time students in approved institutions above the secondary school level. The students must have shown their need for funds and have attained satisfactory scholastic standards. The federal government will carry the interest cost while the student remains in full-time courses and for six months afterward.

Summer employment

Another way of increasing a student's finances is through summer employment. This is particularly valuable when the job is related to science. Work in the laboratories of universities, hospitals, industry and government is often possible. High standing in university studies may be a factor in obtaining some of these jobs. The National Research Council offers a variety of opportunities for summer jobs in its research laboratories on the basis of merit.

Working to continue education

If it is financially necessary to terminate a science course before a degree is obtained, it is sometimes possible to work on a part-time basis while continuing studies. The nature of the job will of course depend on the level of education reached. Some students acquire teaching positions or assistant research jobs, while studying for a post-graduate degree, or, if working for a bachelor's degree, teach at the elementary school level (having met the required teacher qualifications). Under some circumstances, the employer will permit time off for a part-time course and even leave-of-absence for full-time study. In any case, a science student who is serious about a science career and has the ability, should be encouraged to investigate all sources of assistance before dropping a course of study. If it should be necessary to take a job, it is important that it have some relation to the student's field of study.

DEVELOPING EARLY INTERESTS IN SCIENCE

Some interesting points about characteristics and motivations of young people are raised in a book by James Coleman The Adolescent Society. He points out that, because of increasing social sophistication, adolescents are not inclined to be content with a passive role. They spend a large part of their lives in school, where they must sit and be taught, where assignments are commanded. They are expected to conform both in and out of school. If a "floor and ceiling" is put on learning and scholarly effort, creativity and independent thinking tend to be stifled. If a submissive, passive role is forced on young people for such a large part of their lives, they will and must seek outlets for release. Often their energies and discontents may be channeled into worthwhile activities outside of school, such as hobby clubs, debating, school newspapers, drama and music groups, and athletics, where competition is sought and enjoyed.

Parents and teachers are in an excellent position to help young people seek constructive activities which will stimulate science interests. Cultivating a science hobby, while providing a positive outlet, also increases the enjoyment and the knowledge of science on the part of all who participate. Those who have ability and a particular interest in science, would also be encouraged to develop their talents.

The home and the school are the most important influences on the development of young people. When participants in the Canada-Wide Science Fairs have been asked, on filling out their application forms, how they first became interested in science, they have listed teachers, reading and encouragement of parents as most influential. The Radcliffe Survey on women scientists would corroborate this. Many scientists also concur.

- A research chemist writes, "My father was an enthusiastic communication engineer ... Some of his enthusiasm rubbed off onto me. I also had a natural inclination towards scientific subjects, especially mathematics, at school. When at school I read as many 'popular science' books as were then available, particularly biographies. I was determined to be a scientist from the age of 14."

- A palaeontologist, whose father was a sea captain, says that her early environment had great influence on her science career. Her father brought home from his world travels many interesting objects of the sea and curiosities from lands far away.

- An astronomer tells us that her interest in science was stimulated in her home from childhood, especially by the gift at Christmas and birthdays of books, often adult books not fully read or comprehended at the time, but proudly possessed and partly understood.

- A geologist attributes much of her success in studying and undertaking geology as a career, to her father, whose passionate hobby was the study of the natural sciences. His children accompanied him

on his excursions and were accustomed to having their home crowded with speciments of rocks, plants, insects and even the occasional snake!

Ways and means of stimulating scientific interests are many. In the school, the science teacher may accomplish much by such devices as films, bulletins boards, science talks and contests among the students themselves, and by those extra insights some have for making the subject interesting and challenging to the students. If a climate for eager discussion and bold activity is created, extra-curricular pursuits are more likely to thrive.

Competition between groups, classes and schools, rather than between individuals, is valuable. Classroom science demonstrations during school open-house nights; science fair competitions such as those sponsored by the Canadian Science Fairs Council; participation of students in science programs and contests with other schools; science essay contests, such as those of the Royal Canadian Institute - all these are helpful ways of promoting science interests. Scientists invited to speak to the students and also to meet them, visits to nearby university open-house events and research laboratories are also important. For girls particularly, the personal contact with women scientists, a chance to meet and talk with a woman who already has achieved some measure of success, may be valuable.

Also important are trips to museums, observatories and planetariums. These are especially effective when there is a direct relation to school study or science hobby.

The value of good books and periodicals on science, cannot be over-emphasized. Museums and planetariums may not be accessible to many children, but good literature is within the reach of all.

Here are a few examples of clubs and organizations that encourage science interests in young people:

Science and Mathematics Clubs in Schools

If conditions and facilities are right in the school, there is fertile ground for all kinds of club activity. If a science or mathematics teacher has the time to encourage and guide the science interests, students are more likely to carry over their enthusiasms into after-school hours. In small school units, urban or rural, encouragement of extra-curricular activities is more difficult and often impossible, when there is little space, equipment or personnel. With new trends in educational organization and the growth of larger school units on a regional basis, perhaps many of the practical limitations will be overcome.

An interesting development in the establishment of a regional school system, is taking place in the Montreal area. "Cité des Jeunes" is a movement to group high schools on a regional basis, taking students from as far away as 35 to 40 miles, and providing them with transportation to the new school centre, thus gradually eliminating the need for small rural or urban

schools. Educators hope that here at the high school level, an atmosphere similar to that of a college or university will be created - where there may be more stimulus for lively science activity, inside and outside school hours; where high calibre teachers, more resources and facilities and a greater variety of students from different backgrounds, will all combine to make more possible the formation of science clubs and encourage the "cross fertilization" of ideas.

Amateur Naturalist Clubs

Natural history or field naturalist groups are scattered across Canada, with a variety of names and projects. Most of them are connected with schools, museums or universities which provide personnel for leadership and facilities. (For a comprehensive list of these societies, see Chatelaine, March, 1964, page 82, in an article on "Help your child discover ... science", by Eileen Morris). Of special interest to those who wish to pursue activities relating to the physical and earth sciences, are those which include groups that study rocks, minerals and the stars.

The Junior Field Naturalists' Club in Toronto, has a Mineral and Geology Group which conducts an intensive three-year study course. In the first year, a few of the more common rocks and minerals and the tests by which they may be identified, are studied. The members learn about minerals, their identification and uses, in the second year. Elementary geology, including earth structures and glaciation, are studied in the third year. "The big event of the year is the all-day mineral collection trip in May, which is a family outing."

The Royal Astronomical Society of Canada

This is an "organization devoted to the advancement of astronomy and allied sciences". Its membership is open to astronomers, amateur or professional. Special membership is offered to a "student who is certified as being in full-time attendance at a recognized educational institution". The Society encourages and assists the formation of "Centres" which conduct programs independently. There are now 16 such centres across Canada. These often use the facilities and telescope equipment of nearby observatories. All members of the R.A.S.C. receive the bi-monthly "Journal" of the Society and the annual "Observers' Handbook", an excellent guide for star-gazers. Active telescope making, observation and study groups carry on projects in all the centres. On many starry summer nights, in the large cities, you may find eager sky-gazers, old and young, members and friends, gathering in the parks, using their home-made telescopes or, in some cases, borrowing the use of observatory equipment.

PROJECTS FOR YOUNG SCIENTISTS AND MATHEMATICIANS

The Canada-Wide Science Fairs

Every year, for three years now, from the Yukon to Quebec City, from Vancouver to the Richelieu Valley, enthusiastic young participants, winners of an ever-growing number of regional science competitions, arrive at the Annual Canada-Wide Science Fair. This year, 1964, it was held in April at the University of Montreal, in cooperation with ACFAS (l'Association Canadienne Française pour l'Avancement des Sciences). The Canadian Science Fairs Council organizes and directs these annual fairs. It is a non-profit organization sponsored by Canada's major educational institutions and scientific societies.

The top winners of the annual competition, a boy and a girl receive an expense-paid trip to the "International Youth Science Fortnight" in London, England, during the summer. A number of cash awards and research materials are offered to the winners in the two main categories: the biological sciences and the physical sciences.

Top girl winner at the Annual Canada-Wide Science Fair in 1963, Beverly Davies from Belleville, Ontario when asked what science fairs had done for her, has said, "Being able to win and go to England and meet students from all over the world is important ... just being able to work hard on a science project is fun in itself." Further, as a result of her participation in the International Youth Science Fortnight in London, she wrote to the Women's Bureau to say that she would be taking part in this Fortnight in England again this summer as a "courier". She also has been selected, with 51 other science students, to tour Europe on a science trip. "Without the trip to England last summer I could never have had the chance to go again. I am sure that these two trips will affect the rest of my life."

The value of science fairs goes beyond that of the competition. Each participant, on his or her own iniative, has had to prepare a science project from beginning to end - in a limited way, perhaps, very much like the methods used in a science research experiment. They have learned by 'doing' a science project, something of the scientific method and the value of independent thinking. They gain confidence through accomplishment, whether they have won or not.

The qualifications for entering the competitions are stringent, and the quality of some of the exhibits has been on a very high level. No contestant is "under the misapprehension that an incomplete or unimaginative work could be masked by a flashy exhibit." Nor do the"winners consider their science grades as a prime indication of their chances for success." As one finalist expresses it - science fairs "are a good thing because they give recognition to not always the brainiest science student but often the one with ability to work at one thing and make a good project."

Carleton University - Computer Programming for Senior High School

Students and Teachers

For three years running, Carleton University, Ottawa, through the Faculty of Engineering, has offered a course of instruction in Digital Computer Programming for high school students. Students from Grades XII and XIII who show mathematical aptitude and interest may take an eight-week course on Saturday mornings. Participation is on a voluntary, extra-curricular basis, with three students and a teacher invited from each school. No fees or texts are required.

The course covers "the concept of the stored program, elementary computer logic, and programming ... The computational aspects of the computer, as distinct from its business data processing applications" are emphasized. Students, working with their own school team, are given a combination of lectures, workshops and laboratory work in the Computer Room. The culmination of the course is a 2½ hour examination as well as the preparation of two major programs, the results of which are published by team.

Mr. Malcolm Gullen, director of the course, reports, "We believe the course offers a significant challenge to the best of the students and teachers who come to us... Enthusiasm runs high. For the class member, there is the sense of achievement in gaining control of a highly sophisticated machine. Output from the console typewriter is an immediate reward for effort. For the instructor there is the satisfaction at course end of watching a 17 year old youth operate the computer with a touch that approaches the professional. The rate of development of some of these young people is quite remarkable."

Whether such a course is of practical value to a student, will depend on his or her enthusiasm and the time they are able to give to this extra-curricular activity. Sometimes a student's school load is so heavy that the extra reading and time which might be spent on such a course, is difficult to find. This is why one student said, when asked about the computer course, "It would be much better to take an extra course like this while you are in Grade XII. The last year of high school is too busy and crowded with school work, to give the course enough time. The more you put into it, the more you'll get out of it."

The importance of such an experience, however, is that a student who has an aptitude for mathematics, has had the chance to take part in mathematical problem-solving on another level and to gain some insight into the value of the electronic computer for solving problems in many areas of life. This is worthwhile, whether or not the student ever uses computers again. Another valuable by-product of an experience such as this, is that the students have been introduced to the university.

The Royal Canadian Institute - Summer Science Program for Secondary Schools

This summer at the Grove School, Lakefield, Ontario, some 35 boys and girls gathered for a six-week science program. It was the second year that the Royal Canadian Institute had sponsored such a program. It is planned for the bright, intellectually inclined students from Grades XI and XII who have been recommended by schools across Canada and selected by the Institute. Selection is on the basis of merit. Scholarship funds are available to assist those who cannot pay any or all of the cost.

The main objective of the program is to develop "an understanding of science and scientists" through lectures, field trips, laboratory work and discussions. Specialists in a variety of science fields, including guest speakers from universities, give lectures and guide discussion. Daily lecture-discussion periods in mathematics "provide a continuous thread through the programme." There are many opportunities for experiments and projects which involve the use of laboratory and scientific equipment, such as telescopes. Visits to a museum, an observatory and a large research laboratory are part of the program.

The program covers all aspects of science, from geology, astronomy and meteorology through to philosophy and human genetics. In speaking of the 1963 program, Dr. C.D. Fowle says, "No distinctions were made among the basic disciplines of physics, chemistry and biology. Students were encouraged to use the principles and techniques from all three of these to gain insight into problems. In this way the unity of science was emphasized."

The students who have taken part in this program have responded enthusiastically to its challenge. They have enjoyed meeting others with similar interests even though from many different backgrounds. All their activities, their recreation together, the ardent discussions, their encounters with top scientists who challenged them to think, have added up to an exciting experience.

It is hoped too, that the opportunity for a young student to enjoy such a program in a university-like atmosphere will help him or her to find a new approach to study and learning and new insights into all aspects of science. This should help too in making the best use of the last year of high school and in planning a university education as well as in choosing a career.

"Camp des Jeunes Explorateurs"

Cap Jaseux, on the Saguenay River, near Chicoutimi, is the site of a camp for young people of secondary school level who are interested in serious study of the natural sciences. The only requirement, apart from interest in science, is that the applicant shall have had at least eight years of school. Three camps of a two-week period are run during the summer

under the direction of Father Leo Brassard of Joliette College. While the camp at present is for boys only, it is planned that in a few years it will be enlarged to include a camp for girls. Because "Camp des Jeunes Explorateurs" is such a fine example of summer camping experience for a young person interested in the natural sciences, we include it in this survey.

Each camper, on entering the Camp, may select a group of his choice which will concentrate on one aspect of natural science study. They go on field trips, make collections of specimens, do as much research as possible in their chosen subject, work in the camp laboratory, join in discussions, receive some instruction from the grup supervisor, who is a science specialist, and make daily written reports of their findings. Each of them learns in varying degrees how to carry out a research project. From speakers who are invited to lecture and in their discussions, they may also obtain some knowledge of the whole field of natural science.

"Camp des Jeunes Explorateurs", through the nine years of its existance, has accumulated considerable data on the Saguenay region's natural history. All the written reports of those eager "young explorers" of its field and water life, its flora and fauna, its birds, rocks, fossils and marine life, will be a valuable contribution to the natural science history of this little-known area of Canada.

There are other similar nature camps in various parts of Canada. Some are identified with school curriculums and conducted by Boards of Education, such as the Toronto Island Outdoor Natural Science School or one that is being planned in Regina, Saskatchewan. The University of British Columbia is also conducting a pilot project of this type.

FURTHER INFORMATION

Associations

L'ACFAS (l'Association Canadienne Française pour l'Avancement des Sciences) - P.O. Box 6128, Montreal 3, P.Q.

Astronomical Society of the Pacific - c/o California Academy of Science, San Francisco 18, California, U.S.A.

British Astronomical Association - 303 Bath Road, Hounslow West, Middlesex, England.

Camp des Jeunes Explorateurs - c/o Father Leo Brassard, Director, College de Joliette, Joliette, P.Q.

Canadian Association of Physicists - c/o Department of Physics, McMaster University, Hamilton, Ontario.

Canadian Library Association - 63 Sparks Street, Ottawa 4, Ontario.

Canadian Mathematical Congress - 2500 Guyard Ave., Montreal, P.Q.

Canadian Science Fairs Council - 48 Rideau St., Ottawa 2, Ontario.

Carleton University - Dean, Faculty of Engineering, Carleton University, Ottawa, Ontario (for information re Digital Computer Program for High School Students)

Chemical Institute of Canada - 48 Rideau Street, Ottawa 2, Ontario.

Engineering Institute of Canada - General Secretary, 2050 Mansfield Street, Montreal 2, P.Q.

Geological Association of Canada - Box 4029, Terminal A, Toronto, Ontario.

Geological Survey of Canada, Department of Mines and Technical Surveys, Ottawa 3, Ontario.

National Research Council - Sussex Drive, Ottawa 2, Ontario.

Royal Astronomical Society of Canada - 252 College St., Toronto 2B, Ontario.

Royal Canadian Institute - 191 College Street, Toronto 2B, Ontario.

Society of Technical Writers and Publishers, Inc. - P.O. Box 3706, Beechwold Station, Columbus 14, Ohio, U.S.A. (Eastern Ontario Chapter, P.O. Box 2398, Station D, Ottawa, Ontario.

Society of Women Engineers - 345 East 47th Street, New York 17, Room 305, N.Y., U.S.A.

SCIENCE FILMS

National Science Film Library - An agency of the Canadian Film Institute, established in 1962 with a grant from the National Research Council; a national circulating library of films on science and technology, providing

- Information services
- A distributing service
- Programming assistance

Films range from the highly technical for science specialists to those that are suitable for the general public. The Library contains films from many Canadian organizations, industrial and government, and acts as a repository for science films of foreign embassies.

Enquiries and requests for information should be addressed to -

Director,
National Science Film Library,
Canadian Film Institute,
1762 Carling Avenue,
Ottawa 13, Ontario.

National Film Board - Information on science films made and distributed by this agency, may be obtained through local representatives of the National Film Board, through the film divisions of public libraries, or by writing to -

The National Film Board,
150 Kent Street,
Ottawa 4, Ontario.

READING

The following list of books on the physical sciences, the earth sciences and mathematics, was compiled and annotated by the Circulation Division of the Toronto Public Libraries. It covers the general aspects of the sciences, without going into specialized studies or technical books. Biographies of scientists and books on careers will also be found. The list will provide the science-minded young person with interesting basic books in the broad branches of science, and stimulate further reading. Libraries, scientific organizations and museums may provide more detailed and exhaustive lists if consulted.

Asimov, Isaac
The search for the elements. Basic Books. 1962.
A history of chemistry centring on the 2,600 year search for the elements and completing the periodic table.

Baker, Robert Horace
An introduction to astronomy. 8th edition. Van Nostrand. 1964.
Clear and precise presentation of astronomy with a chaper on telescopes.

Baldwin, Ernest
The nature of biochemistry. Cambridge University Press. 1962.
Designed to introduce and integrate the subject without oversimplification.

Beerbower, James R.
Search for the past: an introduction to paleontology. Prentice-Hall. 1960.
An attempt to answer some general questions about paleontology, with numerous line drawings.

Benade, Arthur H.
Horns, strings and harmony. Anchor (Paperback) 1960.
Scientific bases of music and musical instruments.

Berry, Frederick A.
Your future in meteorology. Richards Rosen Press. 1962.
There is a great diversity of activity in the field of meteorology, from weather forecasting to satellite meteorology.

Bibby, Dause
Your future in the electronic computer field. Richards Rosen Press. 1962.
Career book stressing the influence of computers and their applications.

Biddle, Harry C. and Vaughn W. Fioutz
Chemistry in health and disease. Davis. 1962.
Particular emphasis on biochemical topics, as pertaining to health and disease.

Carrington, Richard
A guide to earth history. Chatto & Windus. 1956.
Divided into three parts which unite to form a continuous pattern of evolution.

Carroll, John
Careers and opportunities in electronics. Dutton. 1963.
Introduction to seven careers in this field.

Carson, Rachel
The sea around us. Oxford. 1951.
The science of oceanography is introduced in this fascinating example of popular scientific writing.

Coleman, James Andrew
Relativity for the layman. Macmillan. 1959.
The story behind the theory of relativity and a simple account of the theory itself.

Curie, Eve
Madame Curie: a biography. Doubleday. 1937.
The life story of the discoverer of radium, and the founder of the chemistry of radio-active elements.

Douglas, Alice Vibert
The life of Arthur Stanley Eddington. Thomas Nelson. 1956.
A scientific biography of one of the greatest astronomers of his day.

Einstein, Albert
Relativity: the special and general theory. Crown (Paperback) 1961.
A reprint of the 15th edition...to give insight into the theory of relativity.

Fermi, Laura (Capon)
Atoms in the family: my life with Enrico Fermi. University of Chicago Press. 1954.
Mrs. Fermi's biography of her famous husband, who opened the door to new developments in the fields of atomic and nuclear physics.

Galambos, Robert
Nerves and muscles. Anchor. 1962. (Paperback)
Introduction to biophysics. Scientists now are beginning to understand how impulses are transmitted by nerves, and made to act upon muscles.

Glassner, Alvin
Introduction to nuclear science. Van Nostrand. 1961.
Survey of nuclear science, including a series of eighteen basic experiments.

Harland, Walter Brian
The earth, rocks, minerals and fossils. Franklin Watts. 1960.

Harper, Dorothy
Isotopes in action. Oxford, Permagon Press. 1963.
A Canadian scientist explains the nature, production, and uses of isotopes with particular reference to Canada.

Hogben, Lancelot
Mathematics for the million. 3d ed. W.W. Norton. 1957.
Mathematics can be made exciting to ordinary people.

Jaworski, Irene D.
  Atomic energy; the story of nuclear science, including many home experiments. Harcourt, Brace. 1961.
    Lively illustrations and simple, clear language arouse the interest and curiosity of the layman and junior scientist.

Jeans, Sir James
  Science and music. Cambridge University Press. 1961.
    The science of acoustics is applied to music without the use of mathematics.

Joseph, Joseph Maron
  Point to the stars. McGraw-Hill. 1963.
    An excellent illustrated guide to the constellations as well as planets and satellites.

Kendall, James
  Great discoveries by young chemists. Thomas Y. Crowell. 1953.
    Many important discoveries were made by young scientists such as Faraday and Davy.

Lagemann, Robert T.
  Physical science: origins and principles. Little, Brown. 1963
    Authoritative textbook.

Lehrman, Robert L.
  The long road to man. Basic Books. 1961.
    Evolution of animal life is presented through descriptions of the animals of each rung of the ladder climbing up to man.

Lewis, Amele
  From college to career. Bobbs Merrill. 1963.
    Jobs for college graduates and pointers for high school students planning on going to college.

Moore, Ruth E.
  Man, time and fossils; the story of evolution. 2d ed. Knopf. 1961.
    Evolutionary thoughts from Darwin to the present day.

Muir, Jane
  Of men and numbers; the story of the great mathematicians. Dodd Mead. 1962.
    The lives of twelve outstanding mathematicians from Pythagoras to George Cantor.

Munitz, Milton K.
  Theories of the universe from Babylonian myth to modern science. Free Press. 1957.
    Historical development of man's discoveries about the universe.

Nourse, Alan E.
So you want to be a physicist. Harper & Row. 1963.
The training and work of modern physicists and their role in the scientific world.

Paris, Jeanne
Your future as a home economist. Richards Rosen Press. 1964.
Science points the way to new careers in home economics.

Plot, Helen, comp.
Imagination's other place: poems of science and mathematics. Thomas Y. Crowell. Poets and scientists have a link between them, and sometimes poets have anticipated the scientists.

Pollack, Philip
Careers and opportunities in chemistry. Dutton. 1960.
One chapter "Calling all women chemists" points out the need for women in chemistry.

Pollack, Philip
Careers and opportunities in science. Dutton. 1960.
A survey of all fields in science. American in scope, but of interest to all readers interested in a scientific career.

Riedman, Sarah Regal
Men and women behind the atom. Abelard-Schuman. 1958.
Their schooling, their family life, and their work.

Shamos, Morris H., ed.
Recent advances in science: physics and applied mathematics. Science Editions. 1961. Designed "to convey the basic ideas in some of the newest and most active fields of study".

Simpson, George Gaylord
Life of the past: an introduction to paleontology. Yale University Press. 1953. A clear insight into the work and aims of paleontologists, presenting a fascinating and authoritative picture of fossil life.

Thompson, William E.
Your future in nuclear energy fields. Richards Rosen Press. 1961.
Nuclear energy has a wide variety of applications and unlimited possibilities.

Wendt, Herbert
The road to man. Doubleday. 1959. Written by a well-known anthropologist, this informal history of evolution is remarkable for its sympathy with all forms of life.

Yost, Edna
Women of modern science. Dodd Mead. 1959.
Eleven portraits of gifted women scientists from eleven fields of science.

Zarem, Lewis
Careers and opportunities in astronautics. Dutton. 1962.
Courses and training in the exploration of space. Schools and colleges are in U.S.A., but the information is timely and important.

A list of Paperbacks and Periodicals on Astronomy

prepared by Miriam S. Burland, Dominion Observatory, Ottawa

Paperbacks

This Universe of Space	P. M. Millman (8 radio talks)	C.B.C. Publications Branch Box 500, Toronto.	1961
New Handbook of the Heavens	Bernhardt, Bennett and Rice	Mentor (Signet Science Series)	1952
Stars	Zim and Baker (A Golden Nature Guide)	Simon and Schuster	1951
Radio Astronomy	F.G. Smith	Penguin	1960
Between the Planets	F.G. Watson	Doubleday	1962
Ask a Question about Meteorites	H.H. Nininger	American Meteorite Laboratory, Denver	1961
Earthquakes and Earth Structure	J.H. Hodgson	Prentice-Hall	1964
The Individual and the Universe	A.C.B. Lovell	Mentor	1958
Life in the Universe	M.W. Ovenden (Science Study Series)	Doubleday	1962
Artificial Satellites	M.W. Ovenden	Penguin	1960
Astronomy as a Career	F.D. Miller	Bellman Publ., Cambridge, Mass.	1963
The Observer's Handbook (An annual)	Ruth J. Northcott	Royal Astronomical Society of Canada, 252 College Street, Toronto 2B	1964
Handbook of the British Astronomical Association		303 Bath Road, Hounslow West, Middlesex, England.	1964

Periodicals

Sky and Telescope	Sky Publishing Corpn., (Harvard College Obs.), Cambridge, Mass.
The Review of Popular Astronomy	Sky Map Publ. Inc., Post Office Box 231, St. Louis 5, Missouri.
The Griffith Observer	Griffith Observatory, Post Office Box 27787, Los Feliz Station, Los Angeles 27, California.
Journal of the R.A.S.C. (Bi-Monthly)	Royal Astronomical Society of Canada, 252 College Street, Toronto 2B.
Publications of the A.S.P.	Astronomical Society of the Pacific, c/o California Academy of Science, San Francisco 18, California.
Leaflets of the A.S.P.	Same as above.

Other Paperbacks

Paperbacks are an excellent buy for readers who want up-to-date science books without too much expenditure. Their titles include many books which have already proved themselves as 'hardbacks' and have been reprinted in cheaper paperback editions. Others are completely new titles. The best source of information on reliable, sound paperback science books is the annotated bibliography of 900 selected science books, prepared and frequently revised under the direction of the American Association for the Advancement of Science.

A guide to Science Reading, compiled and edited by Hilary J. Deason, assisted by William Blacklow, with original essays by H. Bentley Glass, Warren Weaver, Margaret Mead and Rhoda Metraux, and Joseph Gallant. A Signet Science Library Book, published in Canada by The New American Library of Canada. 1963. 60 cents.

Some Government Publications

Available from the Canadian Government Printing Bureau, Ottawa.

(Remittance payable to the Receiver-General of Canada must accompany the order)

Rocks and Minerals for the Collector: Sudbury to Winnipeg, by Ann. P. Sabina. The Geological Survey of Canada, Department of Mines and Technical Surveys. 1963. 75 cents.

Rocks, Minerals and Fossils; a brief introduction to Geology, by Eugene Poitevin. 1953. 15 cents.

Miscellaneous Report Series of the Geological Survey of Canada --

Baird, David M. A guide to geology: for visitors in Canada's National Parks. Department of Northern Affairs and National Resources, National Parks Branch, Ottawa. 1960. $1.50.

Baird, David M. Rocks and scenery of Fundy National Park. Report No. 2, 1962. 75 cents.

Baird, David M. Prince Edward Island National Park - the living sands. Report No. 3, 1962. 75 cents.

Baird, David M. Yoho National Park - The mountains, the rocks, the scenery. Report No. 4. 1962. $1.30.

Baird, David M. Cape Breton Highlands National Park - Where the mountains meet the sea. Report No. 5. 1962. $1.00.

Baird, David M. Jasper National Park: Behind the mountains and glaciers. Report No. 6. 1963. $1.50.

Baird, David M. The national parks of Ontario: a story of islands and shorelines. Report No. 7. 1963. 50 cents.

Belyea, Helen R. The story of the mountains in Banff National Park. Report No. 1, 1960. 75 cents.

Pamphlet material, much of it free, may be obtained by writing to the individual federal and provincial government agencies and departments which are concerned with scientific research. Here are a few examples:

Weather services are free. Meteorological Branch, Department of Transport, Ottawa. 1963. Free. (A "pocket guide to Canada's weather service".)

Your future in research. The Employment Officer, National Research Council, Sussex Drive, Ottawa 2, Ontario.

Summer employment. Opportunities for summer experience. A yearly publication. The Employment Officer, National Research Council, Sussex Drive, Ottawa 2, Ontario.

You and the Department of Mines and Technical Surveys. 1964. (Describes briefly the work of all its departments.) Department of Mines and Technical Surveys, Ottawa, Ontario.

How to identify meteorites. 1963. Free. The Geological Survey of Canada, Department of Mines and Technical Surveys, Ottawa, Ontario.

Periodicals

The Canadian Geographical Journal. Official publication of the Canadian Geographical Society, 54 Park Avenue, Ottawa 4. Monthly. $6.00.

"Le Jeune Scientifique". Published by ACFAS (l'Association Canadienne-Française pour l'Avancement des Sciences). Eight issues yearly, October to May. $2.50. Special rates for students. Le Jeune Scientifique, P.O. Box 391, Joliette, P.Q. An excellent science journal for young Canadians. In French.

Natural History. (Incorporating Nature Magazine) Journal of the American Museum of Natural History, Central Park West, at 79th St., New York City, N.Y., U.S.A. Monthly, October through May; bimonthly June to September. $5.50.

Science News. Eight issues yearly, October through May. $1.50 ($1.00 special to groups of students). Science Publications of Canada, 25 Hollinger Road, Toronto 16, Ontario. Brief articles on Canadian science. Should appeal to younger students and be useful to teachers.

Science News Letter. The Weekly Summary of Current Science. $5.50. Science Service Inc., 1719 North St., N.W., Washington, D.C., U.S.A. Up-to-date notes on recent developments in science, with particular emphasis on American news.

Scientific American. Monthly. $6.00. 415 Madison Ave., New York City, N.Y., U.S.A. Reliable and authoritative articles on scientific subjects.

The Unesco Courier. A window on the world. Monthly, except in July and August when it is bi-monthly. $3.00. The United Nations Educational, Scientific and Cultural Organization, Place de Fontenoy, Paris 7, France. Has popular appeal and international outlook; includes articles on education, culture and science; complete issues frequently devoted to science.

The scientific periodicals published by many industries should not be overlooked. Canadian Industries Limited, P.O. Box 10, Montreal, P.Q., publishes a bi-monthly called C.I.L. Oval. International Business Machines, Don Mills Road, Don Mills, Ontario, distributes Think.

Publications on Careers

Timely and reliable information on careers in the physical sciences and mathematics may often be obtained from scientific societies and organizations. (See page 31).

Here are some titles from a variety of sources -

A career in astronomy - 1962 - prepared by the Committee on Education in Astronomy of the American Astronomical Society, Dearborn Observatory, Evanston, Ill., U.S.A.

Careers in statistics - American Statistical Association, 810 - 18th Street, N.W., Washington 6, D.C.

Rewarding careers for women in physics by Elizabeth Wood, 1962. American Institute of Physics, 335 East 45th, St., New York 17, N.Y., U.S.A.

Vocational and technical training for girls in Canada, at high school, post high school and trade school levels of education. Women's Bureau, Department of Labour of Canada, 1963. The Queen's Printer, Ottawa. 75 cents.

Women in Scientific Careers, National Science Foundation. 1961. U.S. Government Printing Office, Washington 25, D.C. 20cents.

Your career as a chemist - A vocational guidance booklet for high school students, 1962. Chemical Institute of Canada, 48 Rideau Street, Ottawa 2, Ontario.

Your career in chemical engineering - Chemical Institute of Canada, 48 Rideau Street, Ottawa 2, Ontario.

Canadian Occupations Monographs, Economics and Research Branch, Department of Labour of Canada -

Careers in engineering - 1960. 25 cents.

Careers in natural science - 1962. 25 cents.

Careers in meteorology - 1958. 15 cents.

The Canadian Government Printing Bureau, Ottawa.

Opportunities for graduates in the physical sciences - 1963 - Civil Service of Canada, Civil Service Commission, Ottawa. Free.

APPENDIX

Divisions and Sub-divisions of the Physical Sciences, the Earth Sciences and Mathematics

The definitions given below provide as short and simple explanations as possible of complex scientific terms. They are based upon the classifications and definitions in Chamber's Technical Dictionary (third ed. 1962) and Occupational Outlook Handbook, 1963-64. (United States Department of Labor). For further information the reader should consult these sources.

PHYSICAL SCIENCES

The physical sciences deal with the basic laws of the physical world and may be subdivided into a number of fields - chemistry, physics, and astronomy.

CHEMISTRY deals with the composition and properties of substances and the changes of composition which they undergo.

Organic	study of the compounds of carbon - the basis of living matter.
Inorganic	study of chemical elements and their compounds other than carbon.
Physical	study of the dependence of physical properties on chemical composition, and physical changes accompanying chemical reactions.
Analytical	analysis by chemical methods to determine the composition of substances.
Biochemistry	chemistry of living things - physiological chemistry.

PHYSICS is concerned with energy in all its forms, with the structure of matter and with the relationship between matter and energy.

Mechanics	study of the action of forces on bodies and of the motions they produce - statics, dynamics, and kinematics.
Heat	study of heat transmission and insulation, high and low temperature effects and phenomena, and heat radiation.

APPENDIX

Light and Optics	study of the nature of light and its wave properties - includes illumination, spectroscopy, and photography.
Sound and Acoustics	study of the generation, perception, measurement, reproduction and control of all kinds of material vibration - supersonics and the reproduction and recording of sound.
Electricity and Magnetism	study of electric currents and allied phenomena.
Electronics	the investigation and application of facts, occurences and circumstances involving the movement of free electrons, as in radio, television, etc. now extended to include applications involving ions.
Nuclear	study of the nature of atoms.
Biological	study of the reaction of living organisms to physical forces, e.g. to heat, light, radiation, sound and electricity - also called biophysics.
Solid-state	study of atomic structure of crystals which led to invention of the transistor used in electronic equipment.
Health	study of radiation hazards, detection and control.
Chemical	study of effects of high temperatures and pressures on chemical substances.
Astrophysics	physical laws applied to the study of interstellar matter and the stars.
Geophysics	the physics of the earth, especially the study of inaccessible portions of the earth by instruments and apparatus.
Plasma	study of ionized molecules derived from gases.
Cryogenics	research and scientific aspects of low temperature production.
Ultrasonics	the science of sound waves having frequencies above the audible range, that is above about 20,000 cycles per second.

APPENDIX

ASTRONOMY studies the universe and all its celestial bodies.

Astrophysics	(see above defintion).
Celestial Mechanics	also called Gravitational Astronomy - the study of the motions of the heavenly bodies under the forces gravitation.
Radio Astronomy	study of the source and nature of celestial radio waves, by means of radio telescopes of extraordinary sensitivity.
Astrometry	measurement of apparent positions of celestial bodies.
Photometry	measurement of the intensity of light.
Spectroscopy of Astronomical Sources	wave-length analyses of radiation from celestial bodies.
Statistical Astronomy	statistical study of large numbers of celestial objects, such as stars, to determine their average properties.

EARTH SCIENCES

The earth sciences are concerned with the history, composition and characteristics of the earth, its oceans, and its atmosphere.

GEOLOGY is the study of the earth's history, structure, and composition as revealed by rock formations and by animal and vegetable fossils.

Palaeontology	study of animal life in past geological periods based on the identification and classification of fossils.
Petrology	study of the origin and the chemical and mineral composition of rocks.
Structural Geology	study of the structure of rocks - where the stratigraphers study the distribution and relative arrangements of sedimentary rock layers in the earth's crust.
Economic Geology	finding and supervising the development of mineral and fuel resources.

APPENDIX

Petroleum Geology	economic geologists here specialize in the discovery and recovery of oil and natural gas.
Mineralogy	economic geologists here specialize in the study of minerals, gems and precious stones.
Geomorphology	study of the dynamic processes of great internal pressures which change the earth's surface - includes erosion, glaciation, volcanic distrubances.
Sedimentology	study of the processes and products involved in the formation of sedimentary rocks.
Geochemistry	study of the chemical composition and chemical changes in the earth's crust.
Astrogeology	application of geological knowledge to the interpretation of data on surface conditions on the moon and the planets, as collected by various means.

<u>GEOPHYSICS</u> is the science concerned with the physical characteristics and properties of the earth - its interior, its atmosphere, its land as well as its bodies of water on its surface and underground.

Geodesy	measurement of size and shape of the earth, determination of the positions, and elevations of points on or near the earth's surface, and the measurement of the intensity and direction of the force of gravity.
Geomagnetics	study of magnetic and electrical processes in and about the earth including such phenomena as sunspots, the aurora, and the transmissions of radio waves.
Hydrology	the study of the water supply of the land areas of the earth, both at the surface and underground - includes glaciers, water supply and irrigation, etc.
Exploration Geophysics	also known as prospecting geophysics - the search for oil and minerals.
Seismology	study of the structure of the earth's interior and the vibrations of the earth caused by earthquakes and man-made explosions.
Volcanology	study of volcanoes, hot springs and igneous rock.
Tectonophysics	study of the structure of mountains and ocean basins, the properties of the materials forming the earth's crust, and the physical forces that cause movements and changes in it.

APPENDIX

METEOROLOGY is the science of the atmosphere - its physical characteristics and movements and also its effects upon the earth and its people.

Synoptic Meteorology	weather forecasting - air pressure, temperature, humidity, wind velocity.
Climatology	the study of climate and its causes in relation to a particular region.
Dynamic Meteorology	investigation of the physical laws governing air currents.
Physical Meteorology	study of the physical nature of the atmosphere, including its chemical composition and electrical, acoustical, and optical properties.
Industrial Meteorlogy	applied meteorology - study of the relationship between weather and specific human activities, biological processes, and agricultural and industrial operations - e.g. air pollution.

OCEANOGRAPHY is the study of the ocean in all its aspects - its characteristics, movements, and plants and animals.

Biological Oceanography	or marine biology - study of the ocean's plant and animal life.
Physical Oceanography	study of the physical aspects of the ocean, such as density, temperature as well as the movements of the sea, such as tides and currents and the relationship between the sea and atmosphere.
Geological Oceanography	or marine geology - study of the ocean bottom - its topography, rocks and sediments.
Chemical Oceanography	the study of the chemical composition of the ocean waters and bottom.

MATHEMATICS

Pure Mathematics is theoretical mathematics, which is concerned with the development of mathematical principles and the discovery of relationships among mathematical forms.

Applied Mathematics develops techniques and approaches, to solve practical problems in the physical, biological and social sciences. The various parts of a problem are analyzed and the existing relationships are described in mathematical terms.

APPENDIX

Mathematical computation, where the mathematician uses his mathematical knowledge to solve complex scientific or engineering problems with the aid of high-speed electronic computers.

Statistics is the use of scientific methods to collect, analyze, and interpret numerical data. Statisticians specialize either in the application of statistical methods to a subject-matter field or in mathematical statistics.

Actuarial mathematics is the use of mathematical methods and techniques in developing and keeping insurance and pension plans up to date. It involves the evaluation of the probability of loss, and the development and analysis of statistical tables on mortality and sickness rates.